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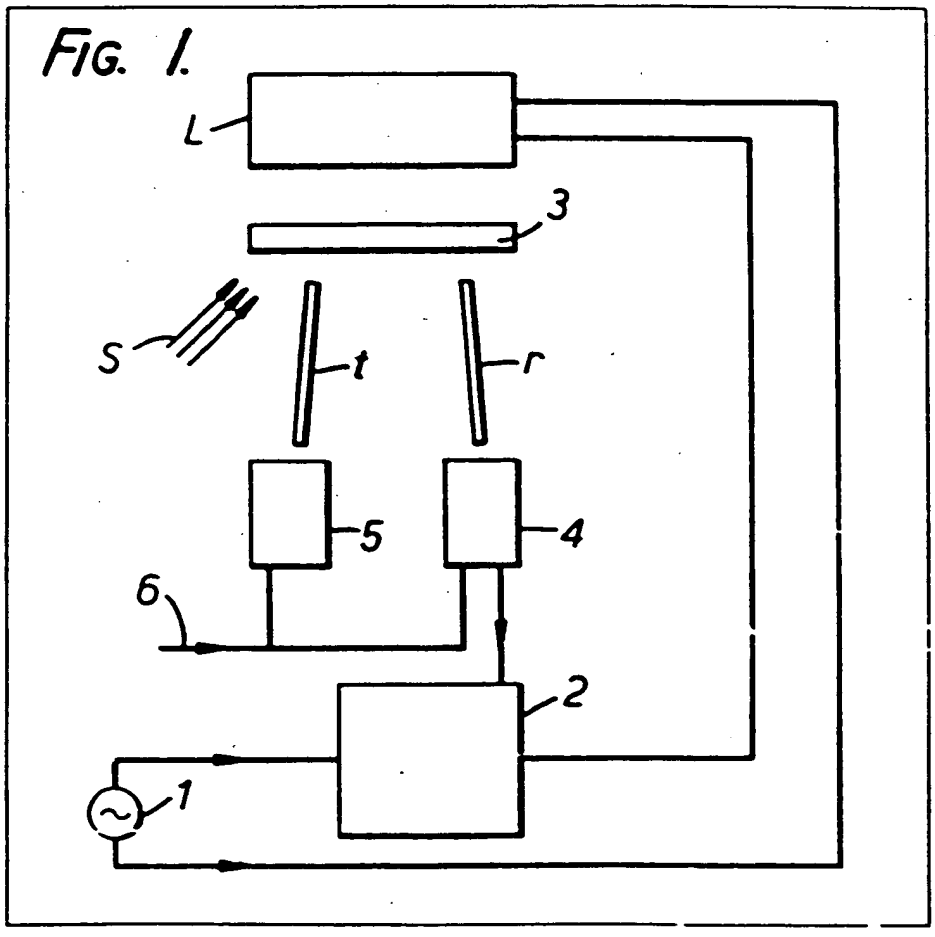
(54) **Temperature responsive device**

(57) A temperature responsive device comprises a temperature sensor 3 having a light reflective (or light transmissive) characteristic which varies with temperature, and means 4 to receive the light reflected from (or transmitted through) the sensor and to provide an output in accordance with the state of the characteristic. As shown, the sensor which may be an adhesive temperature indicator, a liquid crystal, etc is used in a protective arrangement. Sensing of a colour-change, etc of the sensor 3 causes interruption of a switch 2 connecting a power source 1 to a load L, the temperature of which the sensor senses.

FIG. 1.



The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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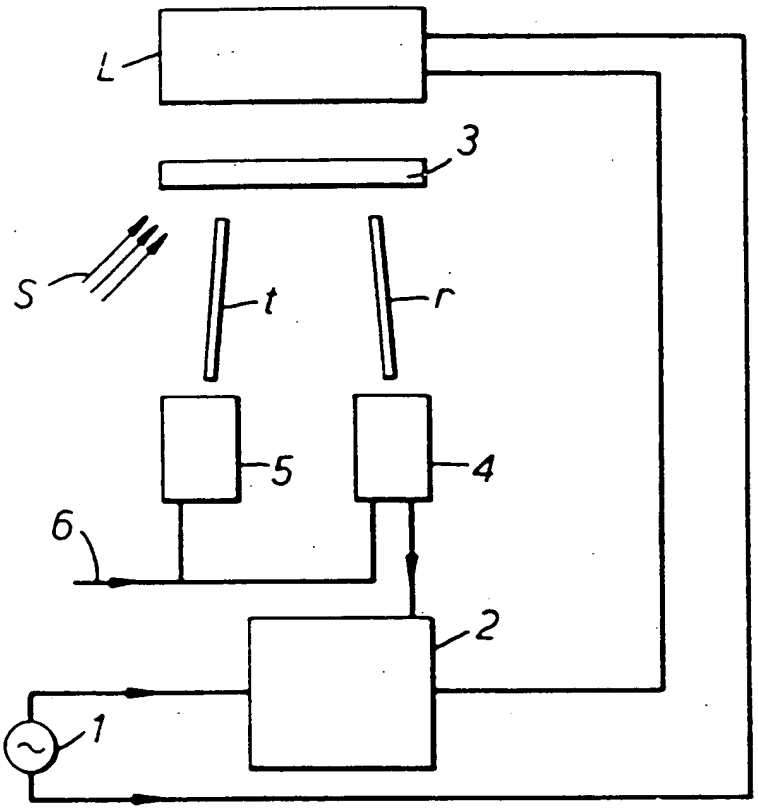
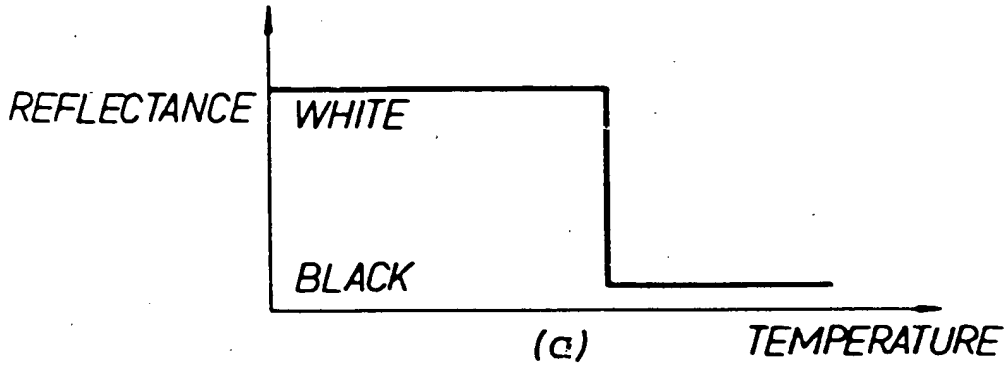

L
3
S
t
r
5
4
6
2
1

FIG. 1.


REFLECTANCE
WHITE
BLACK
(a)
TEMPERATURE

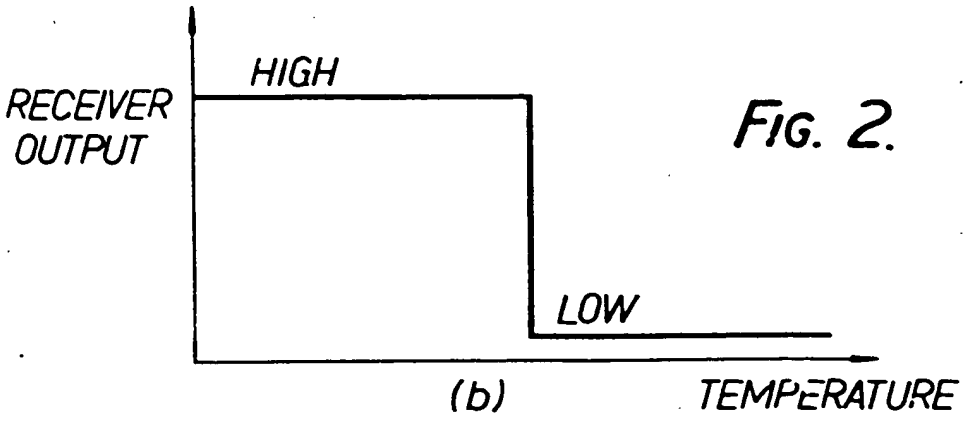

HIGH
RECEIVER
OUTPUT
LOW
(b)
TEMPERATURE

FIG. 2.

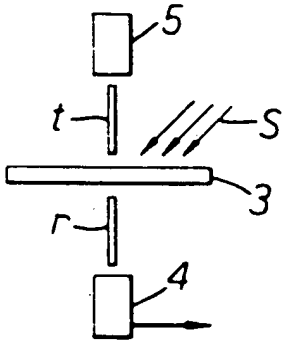


FIG. 3.

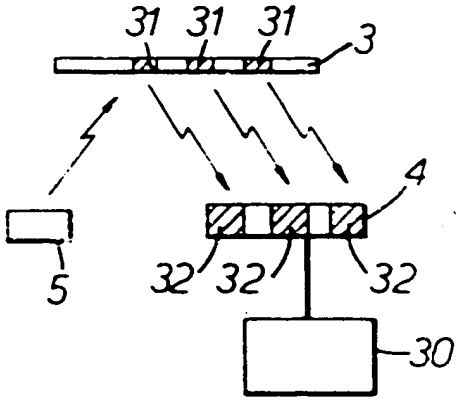


FIG. 6.

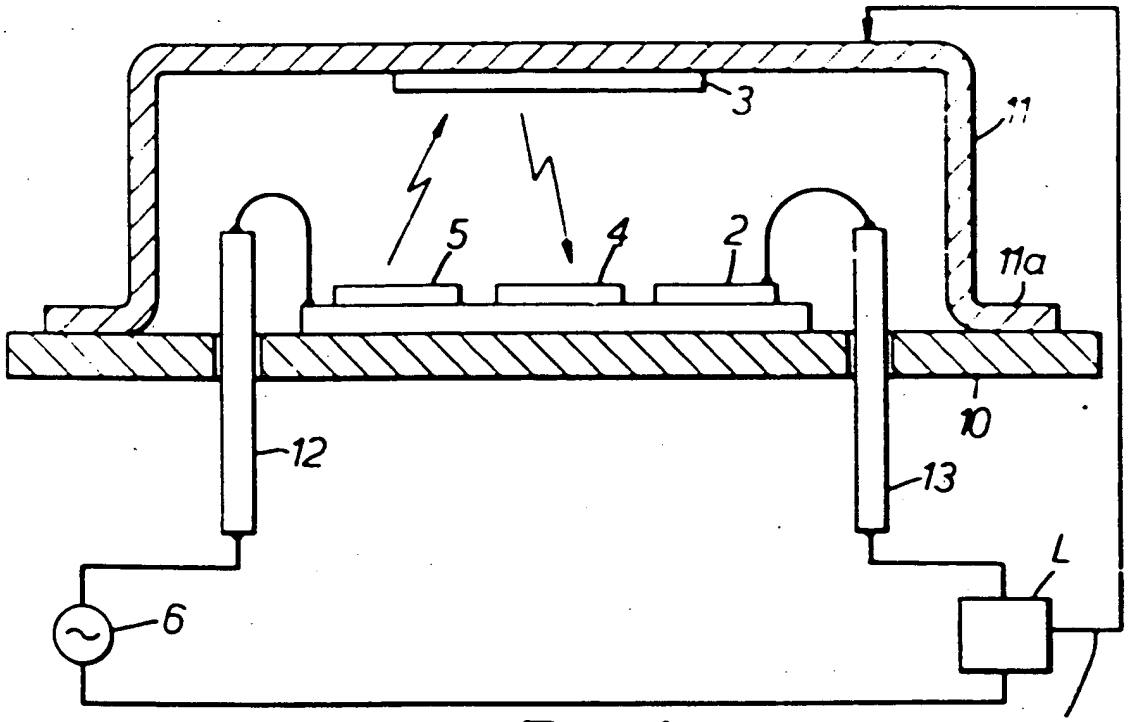


FIG. 4.

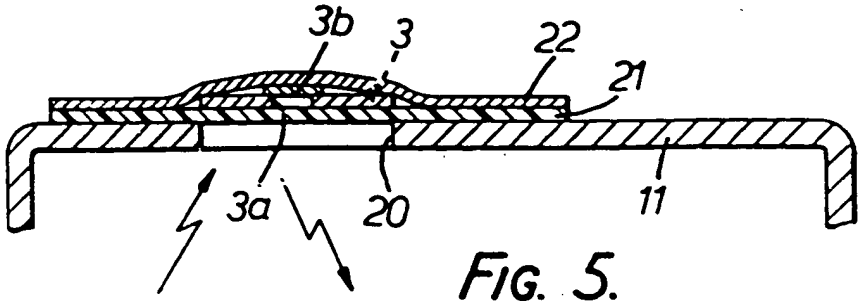


FIG. 5.

SPECIFICATION

Temperature responsive device

This invention relates to a temperature responsive device which in one form may comprise a fuse or thermal overload device for a load supplied from an electrical supply, or in another form may comprise a temperature measuring equipment.

Mechanically-acting fuses are known which effect an irreversible interruption in the current path to a load when a predetermined temperature of the fuse is exceeded. One type of fuse comprises two connector posts with a bridging contact bar secured to these posts by an alloy (for example a low melting alloy). A spring presses against the contact bar so that the contact bar snaps open at the predetermined temperature at which the alloy melts. This is an irreversible fuse and, unlike bimetallic thermal switches, keeps the electrical circuit broken even if the temperature subsequently drops. The fuse is destroyed and must be replaced by another, requiring service personnel. This irreversible function is used as a protective safeguard against overheating in some types of equipment, for example hairdryers: once the apparatus has overheated and the fuse has irreversibly blown, then the cause of the overheating must be located and corrected by skilled personnel and a new fuse must be installed. Irreversible fuses are gaining in favour and regulations by electrical associations and even governments tend to require them as safeguards in certain kinds of apparatus.

Mechanically-acting fuses exhibit poor technical sophistication and low reliability and are costly to produce.

Semiconductor technology offers greater sophistication and reliability and low cost. It is known to employ semiconductor temperature-dependent resistors and these exhibit an abrupt increase in resistance at a predetermined temperature to reduce the current supply to a load. However, when the temperature subsequently drops, the original resistance value is re-established and the full current is again supplied, resulting in thermal overload again. Thus, the use can continue to use the apparatus and this can be dangerous because no skilled repair of the basic fault is enforced.

Electrical or electronic thermal protective circuits are also known. The electrical supply is connected to a load through a thermal protective circuit which includes a sensor responsive to temperature. When a predetermined temperature is exceeded, the circuit is actuated and this may completely break the supply to the load and effect a latch to hold the circuit in this state. A disadvantage of both the temperature dependent resistance device and the thermal protective circuit is that it is not always possible to position the necessary sensor at the critical part of the apparatus.

My present invention provides a temperature responsive device, comprising a temperature sensor having a light-reflective or light-transmissive characteristic which varies with temperature, and means arranged to receive light reflected from or transmitted through said sensor and to provide an output in accordance with the state of said characteristic.

The sensor may comprise a known temperature indicator of the type comprising a label of plastics or the like having a temperature sensitive region formed thereon. At a predetermined temperature, this region changes its total light reflectance or light transmittance or its colour and the receiver responds to this. The sensor may depend for its operation on natural light or upon the provision of an appropriate light source. In any event, the light source and receiver may be remotely positioned from the sensor. Light coupling may be effected by optical fibres.

The temperature responsive device may be embodied as a temperature measuring equipment to provide temperature measurement at a remote location, with the output signal of the receiver being representative of a parameter of the sensor-characteristic (which changes gradually with temperature) and therefore of the temperature. The equipment, including its measuring circuits, need be less complex than for thermocouple temperature measuring equipment. The sensor may instead include a plurality of temperature sensitive areas which exhibit abrupt changes at different predetermined temperatures.

In the case of a fuse, the output of the receiver may control a control means which connects the electrical supply to the load, the arrangement being such that the circuit is broken when the load exceeds a predetermined temperature.

Embodiments of the present invention will now be described, by way of examples only, with reference to the accompanying drawings, in which:

FIGURE 1 is a schematic diagram of a temperature responsive device in accordance with this invention, embodied as a fuse;

FIGURE 2 comprises graphs (a) and (b) showing, respectively, variations of the reflectance of sensor 3 in Figure 1 and of the receiver output with temperature;

FIGURE 3 is a schematic diagram of a modification in which variation in the transmitting characteristic of the sensor is relied upon;

FIGURE 4 is a schematic section through an embodiment of fuse in accordance with this invention;

FIGURE 5 is a similar view through a modified fuse; and

FIGURE 6 is a schematic diagram of a temperature measuring equipment in accordance with this invention.

In Figure 1, an electrical supply 1 is connected to a load L through a control means 2. A sensor 3 is provided in thermal contact with the load L and is arranged to reflect light to a receiver 4 the output of which controls the control means 2. The light incident upon the sensor 3 may be natural light S or may be provided by a light source 5. Electrical supply to activate the source 5 and

receiver 4 is shown at 6 and optical fibr s *t, r* may be provided to guid the light from the source 5 to the sensor and from the sensor to th receiver 4. In operation as a fuse, the sensor exhibits a change in its reflective characteristic with temperature and the output from the receiver is such as to control the control means to reduce the electrical power supplied to the load L. The change in the reflective characteristic may be gradual or abrupt and it may be reversible or irreversible, according to requir..ients. Figure 2 shows a possible abrupt characteristic, in which the sensor changes colour from white to black at a predetermined temperature, causing an abrupt change (from high to low) of the receiver output signal.

Figure 3 shows a modification to the device of Figure 1, in which the light-transmissive characteristic of the sensor is employed. Natural light or light from the source 5 passes through the sensor 3 to the receiver 4. Figure 3 also indicates the possibility of using optical fibres *t, r* to couple light from the source 5 to the sensor 3 and from the sensor to the receiver 4.

Figure 4 shows an embodiment of fuse comprising a metal housing formed of a base plate 10 and a cap 11 which is hermetically sealed to the base plate around a peripheral flange 11*a* of the cap. A heating element or load L of the apparatus being protected is thermally coupled to the cap 11 and the sensor 3 is applied to the inside top wall of the cap. An electrical circuit, comprising semiconductor devices providing the light source 5, receiver 4 and control means 2, is mounted on the base plate and is connected in series between one pole of the A.C. electrical supply 6 and the heating element L by two connector posts, 12, 13 which pass through, but are insulated from, the base plate 10. In this example, the source 5 (for example an infrared-emitting diode), receiver 4 and control means 2 (for example including a triac) are shown as separate semiconductor chips, but in general multi-chip, single-chip, monlithic, or thick or thin film technologies may be employed.

Figure 5 shows a modification of fuse which is readily repairable. A window 20 is formed in the top wall of the cap 11 and is covered by an element of transparent adhesive sheet material 21. The sensor 3 is positioned on the transparent element 21 over the window 20 and a protective cover 22, comprising a piece of metal foil, is secured over the sensor 3 and transparent element 21. The sensor 3 comprises a known temperature indicator in the form of a self-adhesive label of plastics or the like sheet material provided with a transparent window 3*a* b..hind which is mounted an element 3*b* of temperature-sensitive material, so that the temperature indicating region is a dot. For example, this element of temperature sensitive mat rial turns from whit to black upon overheating, whereupon the fuse becomes nonconducting. The repair of the fuse comprises simply replacing the blackened temperature indicator by a fresh one.

It will be appreciated that, in accordance with the inv ntion, the temperature sensor may be positioned r mote from light source, receiver and control means. This enables the sensor to be positioned where it may be subj cted to high voltages, without risk of affecting the other components.

Figure 6 shows diagrammatically a temperature measuring equipment comprising the sensor 3 at the location at which temperature is to be measured, together with light source 5 and receiver 4. The output of the receiver 4 is coupled to a measuring means 30 which provides an indication of the temperature sensed by sensor 3. Sensor 3 may have a characteristic which varies gradually with temperature or it may include a plurality of temperature sensitive dots 31 which change colour abruptly at different temperatures, the receiver having a corresponding plurality of photodiodes 32 and providing an output indication according to which dot or dots change colour.

In each of the embodiments shown the light-reflective or light-transmissive characteristic may exhibit a change in the total light reflectance or light transmittance, for example a change from white to black. Alternatively, the change may be a change in colour-selection, so that a change occurs in the wavelengths of light reflected or transmitted by the sensor.

Particularly in Figure 6, the temperature indicator may be adhesive over its front surface. Suitable materials and chemical compositions for the temperature-sensitive areas are well known and commercially available. For materials exhibiting a reversible colour characteristic, liquid crystals may be used. Material specifications and information is contained in a booklet by NCR Appleton Papers Division, 3400 South Dixi Avenue, Dayton, Ohio, U.S.A. "Chameleon Brand of Encapsulated Liquid Crystals", which also includes a list of supplementary references. Another example is a paint employing appropriate pigments. For example, a 60°C abrupt characteristic is obtained from a composition of 50 grams of Cobalt acetate milled into a resin lik 100 grams "Badacryl" (supplied under this Trade Mark by Imperial Chemical Industries, England) and 50 grams of a convenient solvent to provide a paint composition.

For inversible composition, a paint composition may be prepared for a 235°C characteristic by 50 grams hydrated ferric oxide, 100 grams "Badacryl" resin and a solvent. Another example is to take a very pure chemical with an exact melting point (for example a polymer, a wax, etc) and coat this on a black paper, the black paper no longer being visible under the coating. Upon melting at the predet rmined temperature, th liquid chemical from the coating is absorbed by the paper, or alt rnatively upon cooling goes from opaqu to translucent. In ither case, the black pap r becomes visible.

Another example of n inversible mixture is a mixture of the chemicals orthochloronitrobenzene and orthobromonitrobenzene.

The predetermined temperature of colour-change can in all cases be varied by controlling the ratio of the mixed components.

CLAIMS

1. A temperature responsive device, comprising a temperature sensor having a light-reflective or light-transmissive characteristic which varies with temperature, and means arranged to receive light reflected from or transmitted through said sensor and to provide an output in accordance with the state of said characteristic.

2. A device as claimed in claim 1, in which said light-reflective or light-transmissive characteristic exhibits an irreversible change with change in temperature.

3. A device as claimed in claim 1, in which said light-reflective or light-transmissive characteristic exhibits a reversible change with change in temperature.

4. A device as claimed in claim 1, 2 or 3, in which said sensor is exposed to natural light and said receiver means is arranged to receive said natural light reflected from or transmitted through said sensor.

5. A device as claimed in claim 1, 2 or 3, further comprising a light source directed at said sensor, said receiver means being arranged to receive light from said source reflected from or transmitted through said sensor.

6. A device as claimed in any preceding claim, in which said light-reflective or light-transmissive characteristic exhibits a change in total light reflectance or light transmittance.

7. A device as claimed in any one of claims 1 to 5, in which said light-reflective or light-transmissive characteristic exhibits a change in colour-selection.

8. A device as claimed in any one of the preceding claims, in which said change exhibited by said characteristic is abrupt.

9. A device as claimed in any preceding claim, in which said sensor is optically coupled to said receiver (and to said light source when provided) by an optical fibre.

10. An electronic device incorporating a temperature responsive device as claimed in any preceding claim, comprising means for controlling the supply of electrical power to a load, the sensor being arranged to sense the temperature of the load and the output of said receiver means being connected to control the control means.

11. A fuse as claimed in claim 10, in which a light emitting semiconductor device is provided to radiate light onto said sensor and said receiver comprises a photo-responsive semiconductor device.

12. A fuse as claimed in claim 11, in which said control means comprises a semiconductor power device.

13. A fuse as claimed in claim 10, 11 or 12, in which said sensor comprises a removable and replaceable temperature indicator having a temperature sensitive region formed thereon.

14. A temperature measuring equipment incorporating a temperature responsive device as claimed in any one of claims 1 to 9, the sensor being arranged to sense the temperature at a location and means being provided to respond to the output of the receiver means to indicate said temperature.

15. A temperature responsive device substantially as herein described with reference to any one of Figures 1 to 6 of the accompanying drawings.

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